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ABSTRACT

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An Analysis of Bias in the Selection of School Outliers

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Abstract

A study was conducted to detect possible bias in the prediction of school achievement with family background variables and the effects of biased selection on the classifications of exceptional schools. Bias was examined by testing the equality of subpopulation regressions for predominantly Black, Hispanic and White school subgroups. Significant intercept differences were detected among the subgroup regressions. The effectiveness indices obtained from a multiple regression analysis which failed to control subgroup differences were significantly different from those of a model which accounted for intercept differences. The average effectiveness index for the predominantly Black schools was significantly smaller when intercept differences were not controlled. The indices of Hispanic schools were significantly larger and those of White schools were unaffected. Failure to account for differences among subgroup regressions was found to alter the outcomes of studies aimed at identifying school outliers.

An Analysis of Bias in the Selection of School Outliers

A selection procedure may be considered biased or unfair when the regressions of subpopulations within a target population differ significantly (Cleary, 1969). Subpopulation regressions are unequal whenever the regression slopes or intercepts differ. Whenever differences among subpopulation regressions exist, the use of a single linear regression system for the combined population would penalize one or more of the subpopulations.

In recent years, bias has received considerable attention in educational research. Research in this area has concentrated primarily upon the fairness of individual tests and test items (Scheuneman, 1979; Reschly and Sabers, 1979; Goldman and Hewitt, 1976) and in establishing student admissions and personnel selection criteria (Peterson and Novick, 1976; Boehm, 1972; Cleary, 1968). It has received little attention in efforts to select school outliers which utilize multiple regression procedures. Selection bias, however, could very well be a source of error requiring serious attention in attempts to select "unusually effective" and "unusually ineffective" schools.

School outliers are those schools in which the student enrollment performs significantly above or below expectation. One measure of school effectiveness that has been used to select school outliers has been to compare the school's predicted achievement score with its actual achievement. The school's expected score is derived by regressing school achievement scores on family background variables. The residuals of the multiple regression analyses serve as the school effectiveness indices.

The findings and discussions of some studies, however, suggest that the regressions which relate achievement measures with certain student inputs may not be equal among students of different sociocultural groups (Coleman et al., 1969; Mayeske, 1973; Hanushek, 1972). The possibility of unequal regressions for various ethnic groups has important implications for studies which focus on the identification of school outliers. The possible moderating effect of sociocultural background on the relationship of student background with school achievement may have a significant impact on the identification of school outliers since a school's estimated performance score could change considerably as a result of differential subgroup prediction. Consequently, the effectiveness indices could differ significantly.

This study addresses two research questions which are related to this issue. Are the regressions which relate family background measures with school achievement within predominantly Black, Hispanic and White school subgroups identical? What effect do differences among the subgroup regressions have upon the size of school effectiveness indices and the selection of unusually effective and ineffective schools?

Findings of studies which have investigated the differential influence of school variables on school achievement among sociocultural groups provide indirect evidence that the overall impact of family background variables may differ among ethnic groups as well. Several researchers have concluded that school variables account for a greater proportion of the achievement variance within Black subpopulations (Mayeske, 1973; Smith, 1973; Coleman et al., 1969) and that significant interactions exist between ethnic background and school

related variables (Summers and Wolfe, 1974; Bargen and Walberg, 1974). If, in fact, the proportion of the total achievement variance accounted for by school variables is larger for minority students, then one of two possible results occur. Either the joint school and family background variation is less within minority subgroups or the fraction of variance due to family background variables is smaller.

The findings of Mayeske (1973) lend support for the latter possibility. Mayeske calculated the unique and joint effects of school and family background variables to assess the relative importance of each in the prediction of verbal achievement for Blacks and Whites. The importance of family background variables for predicting verbal achievement was found to be substantially less for Blacks and lower socioeconomic students than for Whites and high socioeconomic students.

Smith (1972), in a reanalysis of Coleman et al. (1969) data for Black and White school subgroups, found that the effects of family background variables upon the verbal achievement of the school subgroups differed. The effects of these variables on verbal achievement was stronger for Whites. Whites were more influenced by the educational climate of their homes whereas economic conditions were most related with the achievement of Blacks. In grade six, for example, eight family background variables accounted for 52% of the verbal achievement variance within White schools as compared to 35% within Black schools.

In this study subgroup regressions which related family background measures with school achievement were compared to determine differences in

variance account for by family background. These comparisons were made by analyzing differences among the slopes and intercepts of the subgroup regressions. This analysis provided a direct test for biased predictions, the criteria for fairness being the equality of the regression systems. In cases where the regressions differed,the study further investigated the effects of the biased predictions on attempts to identify unusually effective and ineffective schools.

Method

Sample

The Florida Statewide Assessment Test is administered annually to public school students in Florida who are enrolled in grades three, five, eight and eleven. This study analyzes the school-level data of the fifth-grade examinees in the Dade County, Florida public school district. The sample included 153 elementary schools and one middle school which had fifth-grade student enrollemnts.

The sample was subdivided into schools with student compositions that were predominantly White (N=64), predominantly Black (N=42) and predominantly Hispanic (N=48). Ethnic composition was operationally defined as the ethnic subgroup with the highest percentage of student enrollment.

Independent and Dependent Variables

Mean school achievement scores on the communications section of the 1977-78 edition of the Florida Statewide Assessment Test were used as the

dependent variable. Items which appear on the instrument measure reading, writing, vocabulary development and study skills. The items are based upon statewide minimal objectives which students are expected to attain. These objectives are assumed to be independent of any particular instructional method.

Measures of student and family characteristics were used as predictors for deriving an estimated school achievement score. These variables were:

1. the percentage of minority students enrolled in the school;
2. the percentage of students in the school who met eligibility requirements for a free or reduced price lunch;
3. the percentage of students whose parent or guardian attended college;
4. the percentage of students from families whose head of household was employed in a white collar occupation.

Measures of the first two variables were obtained from district survey data. Values for variables three and four were estimated for each school by the school's principal.

Analysis

Effectiveness Indices

The measure of a school's level of effectiveness was the difference between it's expected level of performance on the assessment test and the actual mean test score for the school. Mean communications scores were regressed on the four background measures under three regression model specifications. The residual scores obtained from each of the analyses consti-

tuted the school effectiveness indices. These scores are the school means which would br expected when family background of students is controlled. A school was considered to be an outliers if its effectiveness index exceeded a specified standard error of estimate level.

Regression Models

Model I (Interactive Regressions). Model I took into account the differences among the slopes of the subgroup regressions. Communications scores were regressed on two group membership vectors and seperate subgroup predictor vectors. Schools were classified as predominantly Black, Hispanic or White. Dummy coding was employed to indicate group membership, where 1 indicated membership within an ethnic subgroup and 0 indicated nonmembership. Seperate predictor vectors were created by obtaining cross products of the group membership vectors and each predictor variable vector.

Model II (Parallel Regressions). Within model II, differences in the intercepts of subgroup multiple regressions were controlled. Group membership vectors and predictor vectors for the total sample were used as controls. Predictor vectors contained the values of each predictor variable for all three subgroups. School achievement scores were regressed on the group membership vectors and four predictor vectors.

Model III (Linear Additive Regression). The ordinary least squares model was based upon the assumption that the slopes and intercepts of the subgroup regressions were equal. Mean achievement scores were regressed on combined group predictor vectors.

Test for Equality of Slopes

In order to determine whether the subgroup planes were parallel when regressing school achievement on family background variables, the proportion of achievement variance accounted for by predictor variables, R^2, under Model I was compared with the R^2 associated with Model II. This procedure is described by Kerlinger and Pedhazur (1973). The increment in R_2 which resulted from use of seperate subgroup vectors as opposed to combined group vectors was tested using an F-ratio at p .05. A significant F-ratio indicated that the multiple regressions were not parallel.

Test for Equality of Intercepts

A test for the equality of intercepts was made only when the slopes of the regression planes did not differ significantly. The test determined whether evidence was sufficient to support fitting the data to a single regression plane for the total sample as compared to seperate planes with unequal intercepts. The test of intercept differences was performed by comparing the proportion of communications variance account for by combined predictor vectors (Model III) and the proportion of variance accounted for by group membership and combined group predictor vectors (Model II) using an F-test at p .05.

Analysis of School Effectiveness Indices

School residuals for each of the three models were used as school effectiveness indices. Because use of seperate group predictors could result in significant school outlier changes without an appreciable R^2 increment, the effect of the models on school indices were examined regardless

of outcomes of the F-tests. Analyses of the residuals were made by examining the correlations between the school classifications produced by the models; analyzing the agreement between corresponding school outliers identified by the models at 1.0, 1.5 and 2.0 standard error of estimate intervals; and analyzing tye type of school classification changes which occurred with model changes.

Results

Table 1 present the means and standard deviations of family background variables and school communications scores within the total group and school subgroups. With the exception of percent white collar employment and percent of parents with some college education, differences between the variances were small and appear to be homogeneous. These two variables, however, produced the smallest effects on achievement after other variables had been controlled. The effect of differences in variance constriction among subgroups on differential validity of variables was probably minimal.

Insert Table 1

Table 2 displays summary information for the regression models that were compared in the study. The table contains regression coefficients for each model, standard error of estimates, and F-ratios.

Intercorrelations among the variables for the total group and ethnic subgroups appear in Table 3. Although correlations between the variables

tended to be rather high, multicollinearity was not considered to be a study limitation since the effects of individual family background variables were not investigated. Only the overall effects of these variables were considered.

Insert Table 2

Insert Table 3

Equality of Regression Slopes

Findings of the F-test did not support the hypothesis of unequal slopes for the subgroup regression planes. A test of the R^2 increment associated with Model I over that produced by Model II revealed no significant differences in the regression coefficients of the predictor variables across the school groups ($F=1.06$; $p>.05$; $d.f.=8,139$). Use of the seperate predictor vectors produced an increase in the proportion of explained achievement variance of only .014.

The observed increase in the multiple correlation relating communications achievement and seperate group background vectors was accompanied by a small increase in prediction payoff. A substantial increase in prediction payoff was hindered by the slow reduction in residual sum of squares due to the high intercorrelations among the predictor vectors and the loss of degrees of freedom. Lack of statistical significance was also influenced by the small sample size.

Equality of Regression Intercepts

Whereas statistical tests indicated no significant slope differences among subgroup regression planes which related achievement with background variables, analysis of intercept differences revealed that the subgroup regression planes were not identical. The linear additive model accounted for 72.92 percent of the school mean communications score variance. Group membership vectors, which controlled for subgroup intercept differences, accounted for a significant increment of 2.46 percent in communications achievement score variance ($F=7.63$; $p<.05$; d.f.=2, 147).

This finding indicates that the school achievement scores of at least one of the school subgroups differ systematically from those of the remaining subgroups even after family background controls are introduced. The common group regression plane which relates school achievement with family background without taking group intercept differences into account fails to emphasize this systematic group difference.

Impact of Intercept Differences on School Outliers

Comparisons of residual means for the equal slope (Model II) and linear additive (Model III) regression models confirmed the systematic group differences that occurred as a result of significantly different intercepts for subgroup planes. These means appear in Table 4. The means of Model II and Model III were compared using the t-test for related samples. Schools within predominantly Black subgroup were significantly overpredicted by the linear additive model ($t=6.5$; $p<.05$; d.f. = 82). The difference between the mean residuals of predominantly Hispanic schools was statistically significant

(t=7.98; p .05; d.f. = 94), and results indicated underprediction of the performance for these schools by Model III. The difference between the means for predominantly White schools was not statistically significant. Consequently, predominantly Black and Hispanic schools are most affected by the choice of a regression system; predominantly White schools are not affected to a significant degree. The use of Model III had the effect of making Black school performance appear to be worse than actuality and revealed Spanish schools as more positive performers than would be indicated by the equal slope model.

Insert Table 4

The school classifications derived from the equal slope model (Model II) were compared with the classifications produced by the interactive model (Model I) and the linear additive model (Model III). These comparisons appear in Table 5 through Table 7. The number of outliers produced by the models did not differ to a great extent. The smallest number of outliers was produced by Model I. Although there was not an appreciable difference in the number of outliers produced by the models, there was some disagreement in the schools that were classified as exceptional.

Phi coefficients were calculated between the school classifications under Model II and Model III to determine the degree of similarity between the school classifications. The largest coefficient, .82, was obtained for classifications at $\pm$1.0 S.E.E. Coefficients of .79 and .57 were obtained

at $\pm$1.5 and $\pm$2.0 S.E.E., respectively. These coefficients indicate a moderate agreement in the school classifications of the two models.

With each successive S.E.E. increase, the proportion of discrepancies in the classifications of the schools between Model II and Model III increased. At $\pm$1.0 S.E.E., only 75% of the school outliers were common to both Model II and Model III. At $\pm$ 1.5 S.E.E. and $\pm$2.0 S.E.E. levels, only 68% and 42% of the outliers were agreed upon by both of the regression models.

The comparisons of the classifications resulting from Model II and Model III indicate that the outlier status of a significant number of schools under Model III would change if achievement estimates were derived from Model II. Failure to account for significant intercept differences among the subgroup regressions would adversely affect the outcomes of school effectiveness studies by identifying a number of invalid school outliers.

Possibly because differences in the proportion of achievement variance accounted for by Model I and Model II were not statistically significant, there was greater agreement between the model with regard to school classifications than between Model II and Model III. Phi coefficients between the school classifications of the interactive and equal slope regression models were .86, .77, and .88, respectively. These coefficients indicate a relatively high level of correspondence between the classifications of the two models.

The number of discrepancies between the outliers identified by the models may be obtained from the table presentations. Of the total 34 outliers that were identified at $\pm$1.0 S.E.E., 27 or 79% were selected by both

models. At the $\pm$1.5 S.E.E. level, there was 65% agreement, and at $\pm$2.0 S.E.E. there was 78% agreement in the outlier classifications.

Insert Table 5, Table 6, and Table 7

Summary

A comparison of the linear additive, equal slope and interactive regression models was made to determine which model most accurately represented the relationship of family background variables with school achievement and the effect any differences would have on the classification of schools as outliers or nonoutliers. The findings indicated that the regressions of Black, Hispanic and White school subpopulations were not equal as a result of significant intercept differences. Use of the linear additive model which failed to adequately control subgroup intercept differences yielded biased estimates of school performance for the Black and Hispanic subpopulations. Use of the model would result in a greater difficulty for predominantly Black schools to approach outlier status since achievement estimates are overpredicted, thereby yielding smaller effectiveness indices. Hispanic schools would benefit from use of the procedure because their predicted achievement scores are underestimated. The estimates of predominantly White schools are only slightly affected.

Differences with regard to the impact of family background upon achievement with various ethnic subgroups may result from inadequate measurement of

background variables. Hanushek (1972) states that differences in the structure of the production functions amoung subgroups might be expected as a result of the psychological, economic and cultural differences which exist among the groups. The family background variables which are related to achievement serve only as proxies for a complex set of attitudes, interests and educational backgrounds. However, the transformations between the background variables used in most studies and the more relevant background attributes may not be equal for Blacks and Whites as a result of distortions caused by racial discrimination. Therefore, it is possible that the background variables may not have equivalent meanings across subgroups due to inconsistent measurement.

Smith (1972) states that differences in the mean achievement levels of various ethnic and socioeconomic groups which remain even when background and school controls are introduced, suggest that unmeasured factors influence achievement according to student types. Such differences tend to affect the respective regression ceofficients of the subgroups.

If, as posited by Hanushek and Smith, the group membership variables serve as proxies for family background measures, then Model II (parallel regressions) may be considered preferable to Model III (linear additive).

Several study limitations are noteworthy. One limitation involves the measurement error associated with the family background variables. The percent of parents with some college education and the percent of parents employed in white collar jobs were derived from principals' estimates. Certainly these estimates vary in their degree of precision. The estimates were also invluenced by the efforts of principals to obtain accurate information and the

image principals desired to portray regarding their schools. The percentage of students receiving a free or reduced price lunch was also influenced by principals' efforts to secure necessary forms from all eligible students.

The size of the school sample may have resulted in the failure to detect significant slope differences among subgroup family background predictors. Although differences existed in the school classifications of Model I and Model II, the classifications associated with the interactive model are not supported by significant slope differences. Perhaps the differences would have reached significance with a larger sample size.

These limitations warrant replications of this and similar studies using additional family background predictors and larger samples. The effects of other moderator variables, such as socioeconomic status, are also worth investigating. Longitudinal designs should be incorporated in future studies to substantiate the consistency of such findings within a population.

The results of this study, however, clearly suggest that investigations for unequal production functions across ethnic subgroups should be conducted prior to the selection of school outliers in future school effectiveness studies. The outcomes of these studies can be dependent largely upon the nature of differences among the subgroup regressions. The use of an inappropriate and biased regression model could affect the number of outliers and the classifications of specific schools. Decision-making based on the results of a linear additive model could be unfair for one or more of the school subpopulations.

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Table 1

Means and Standard Deviations of Family Background and Achievement Variables in the Total Group and School Subgroups

	Mean (Standard Deviation)			
	Total (N=154)	White (N=64)	Black (N=42)	Spanish (N=48)
Var 1: % minority students	59.60	27.98	90.75	74.50
	(30.44)	(13.83)	(11.31)	(13.86)
Var 2: % white collar	34.38	52.91	15.00	26.65
	(26.08)	(26.62)	(12.04)	(16.57)
Var 3: % college education	26.73	41.41	13.12	19.08
	(22.71)	(24.48)	(12.67)	(14.72)
Var 4: % F/R lunch	43.96	21.43	78.82	43.51
	(28.57)	(16.30)	(14.33)	(18.56)
Var 5: Communications Achievement	48.93	51.70	43.21	50.25
	(4.77)	(2.98)	(3.76)	(2.92)

Table 2

Standardized Regression Coefficients

of Family Background Variables

	Model I	Model II	Model III
Group Membership			
White	.160	-.094	
Black	.218	-.236	
Free/Reduced Lunch	-	-.789	-1.024
White	-.547		
Black	-1.202		
Hispanic	-.465		
% Minority Enrollment	-	.108	.172
White	.086		
Black	.163		
Hispanic	217		
% Parents With College Educ.	-	-.004	-.032
White	-		
Black	-.012		
Hispanic	.026		
% White Collar	-	.022	-.016
White	-.033		
Black	.015		
Hispanic	-.021		
R^2 =	.768	.754	.729
F-ratio	35.68	90.51	100.30

Table 3

Intercorrelations Between Family Background Variables and School Variables

		% minority	% white collar	% college	% F/R lunch
TOTAL SCHOOL SAMPLE	% white collar	-.72			
	% college	-.64	.76		
	% F/R	.83	-.74	-.65	
	achievement	-.65	.59	.51	-.85
BLACK SCHOOLS	% white collar	-.34			
	% college	-.26	.23		
	% F/R	.82	-.36	-.37	
	achievement	-.45	.22	.19	-.56
HISPANIC SCHOOLS	% white collar	-.57			
	% college	-.36	.53		
	% F/R	.46	-.56	-.43	
	achievement	-.14	.26	.25	-.56
WHITE SCHOOLS	% white collar	-.45			
	% college	-.48	.74		
	% F/R	.62	-.70	-.60	
	achievement	-.46	.58	.48	-.85

Table 4

The Means and Standard Deviations of the Residuals Produced by the Regression Models for Each School Subgroup

	Mean (Standard Deviation)		
	Interactive	Equal Slope	Linear Additive
Black Schools	.0005	-.0002	-.7536
	(3.10)	(3.13)	(3.11)
Hispanic Schools	-.0423	-.0004	.7640
	(2.38)	(2.51)	(2.72)
White Schools	.0003	.0000	-.0781
	(1.52)	(1.60)	(1.53)

Table 5

The Number and Type of School Classifications of the Models at ±1.0 S.E.E.

Model II

Model III	Model I	Outlier	No Outlier
No Outlier	No Outlier	4*	118
	Outlier	27	5*
Outlier	No Outlier	2*	120
	Outlier	27	5*

*Schools which were missclassified by Model I and Model III.

Table 6

The Number and Type of School Classifications of the Models at ±1.5 S.E.E.

		Model II	
		Outlier	No Outlier
Model III	No Outlier	3*	135
	Outlier	13	3*
Model I	No Outlier	1*	137
	Outlier	11	5*

*Schools which were missclassified by Model I and Model III.

Table 7

The Number and Type of School Classifications of the Models at ±2.0 S.E.E.

		Model II: Outlier	Model II: No Outlier
Model III	No Outlier	4*	142
Model III	Outlier	5	3*
Model I	No Outlier	2*	145
Model I	Outlier	7	0

*Schools which were missclassified by Model I and Model III.